decreasing thunder and the display of distant lightning. But in the center of this commotion we often get terrific thunder, lightning, and rain, shaking our houses like an earthquake. Last week three head of cattle were killed here by lightning, and on the very high mountain valleys amongst the tall timber many pine trees are ruined every year by lightning. The season of these storms lasts from July to early in October. The weather conditions during the three months of their duration are about as on the accompanying weather map (fig. 2) in the southwest corner "low." At its commencement the weather forecaster usually says of this low: "The usual summer conditions prevail in the southwest," or words to that effect. The only reports to the Weather Bureau of rainfall from this section are from Campo, Cuyamaca, and Nellie. For a number of years I reported for Laguna, but the frosts burst three rain gages for me. During the building of Moreno dam, reports were received from that place.

THE SANTA ANNA OR DESERT WINDS.

While I was writing the preceding lines another of our California climatic visitants with a Mexican name commenced on the 16th instant, the "Santa Anna", so called from the town of Santa Anna, near Los Angeles, where they blow with great violence and with volumes of dust so as to obscure the sky while they last. They are northers or "norther winds" there, and also in the big San Joaquin Valley of upper California. I was once lost there for three days, in one of them, and probably was not more than three miles from home all the time. In San Diego County we call them desert, or east winds; they come to us straight from the east, while in the desert they are west winds. They blow during periods of three to six or nine days, but rarely last beyond twenty-one days. They are cool winds to us here on the mountains, while on the coast they are hot, and are skin-drying, lip-cracking, unpleasant visitants. After they reach the coast the force is mostly out of them. Sometimes their force at Campo rivals a hurricane. In places they pierce window panes with little round holes as if drilled by the coarse gravel they carry like a dose of small shot. On my ranch on the Laguna Mountains, at an elevation of 6500 feet, all the east side is in big pine and oak timber for some miles; yet on the last ridge, overlooking the desert on the east, not a tree grows for miles, altho north and south they grow up to within 200 yards of it all along. Even the brush changes on that last ridge from a growth of six to ten feet down to all dwarf, creeping and clinging close to the ground, but of the same varieties as the upright. These winds are so violent that they often tear down houses. Their duration is from October to March. We generally get our first fall rains after the blow is over, but this year the first rain, on the 15th, preceded this one. If they come in the spring after the fruit blooms or forms, both the bloom and the young fruit drop off the trees after a short time. The barometer responds more quickly to an east wind than to any other change of weather.

HAS THE GULF STREAM ANY INFLUENCE ON THE WEATHER OF NEW YORK CITY?[1]

SIR: Your letter of September 14, requesting information as to supposed variations in the course of the Gulf Stream, and the possibility of the variations acting as a controlling factor in the climate of the city of New York, has been received.

The Bureau is in almost daily receipt of inquiries of this and a similar nature, all having their origin in a misconception of the character and extent of that motion of the ocean waters to which the name Gulf Stream may properly be applied. Speaking with precision, the term should be limited to that continuous discharge of the water of the Caribbean Sea and the Gulf of Mexico which takes place thru the Straits of Florida, a narrow outlet bounded on its western side by the State of the same name, and on its eastern by Cuba and the Bahama Islands and Bank. Thru this channel, constricted in its narrowest portion to a width of 32 miles, there is a constant outflow of the warm, equatorial waters heaped up in this vast and almost landlocked basin by the persistent action of the trade winds, rising at times in mid-stream to a velocity of four or five knots, and having a constant temperature of 81° or 82° F. The impetus imparted to this water by the pressure from the rear is moreover sufficient to maintain it in motion for a considerable distance beyond the actual point of exit from the channel proper, which may be considered as terminating at Matanilla Shoal, the northern extremity of the Great Bahama Bank, in latitude 27° north. As a result the stream continues to be felt as a distinct body of warm water about forty or fifty miles in width, moving steadily onward, but with uniformly diminishing velocity and temperature, until a point opposite Cape Hatteras is attained, or even opposite the Capes of the Chesapeake. Beyond this point, however, the warm current spreads out over the adjacent area of the ocean like a vast fan, and the identity of the stream is consequently obliterated in the general eastward drift which characterizes the waters of the temperate latitudes.

Speaking then with precision, the Gulf Stream is a current of warm water, forty or fifty miles in width, which emerges from the Straits of Florida, follows the coast of the United States northward as far as the Capes of the Chesapeake, and is there merged in the generally eastward drift underlying the prevailing westerly winds of the temperate latitudes. To describe it in the language of Maury as "a river in the ocean, having its fountain in the Gulf of Mexico, and its mouth in the Arctic Seas" is picturesque, but highly exaggerated and erroneous.

With reference to movements of the stream (viz changes in its location as a whole), reports of which, furnished by navigators, appear from time to time in the daily newspapers, it may be said that these probably do exist, altho within narrow limits. Observations of the "set" experienced by vessels crossing the stream, as also of the warmth of the surface waters, show that the position of the axis, or line of greatest velocity, as also that of the line of maximum temperature, may vary from day to day over a range of fifty miles. The methods of observations employed are, however, so replete with sources of error that little confidence can be placed in any single result. That such movements can have any effect upon the climate in the vicinity of New York is highly improbable, the stream itself in these latitudes being so dispersed as to be almost indefinable, and the modifications of the surface temperatures of the adjacent waters wrought by a temporary change in its position being certainly negligible.—*J. P.*

[1] The above letter, by Mr. James Page, was sent in reply to a gentleman who had been told that a mild winter in New York city was due to the fact that the Gulf Stream is running 60 miles nearer shore than previously. We hope that its publication may contribute to correct the numerous popular misapprehensions relative to the important part played by the Gulf Stream in the economy of nature.—EDITOR.

ON THE FORMATION OF ANCHOR ICE, OR GROUND ICE, AT THE BOTTOM OF RUNNING WATER.

By H. T. BARNES, D. Sc., Associate Professor of Physics, McGill University, Montreal. Dated December 4, 1906.

A recent paper[1] on ground ice, by M. J. de Schokalsky, calls attention to the formation of ice at the bottom of Lake Ladoga, near St. Petersburg, and a general description of the ice was given. No suggestions were made, however, as to the cause of the phenomenon, and it was stated that beyond the important report of M. F. Wladimiropp[2], little attention had been directed to the study of it. For the past ten years the writer has been observing, from time to time, the same

[1] Comptes Rendus, vol 143, p. 261 (1906). Science Abstracts, vol. 9, p. 455 (1906).

[2] Water Works Commission, St. Petersburg (1904).

thing in Canadian waters, where the severity of the climate in winter brings about the growth of immense masses of ground ice. In America the ice goes by the name of anchor ice from its being attached or anchored to the bottom, and has been so called since 1830. It has been observed in all countries where river ice is formed and has been called "ground ice", "bottom ice", "ground gru", a name given it by the inhabitants of Aberdeenshire, "lappered ice", by the common people of south Scotland, "glace de fond", by the French, and "Grund eis", by the Germans. The French-Canadian expression is "moutonne", from its resemblance to the white backs of sheep at rest. The phenomenon of ice forming on the bottom of rivers has been known for a very long time, and altho the majority of the early philosophers of France denied its existence it was perfectly well known to every peasant.

In 1788 M. Beaun wrote several papers to establish the existence of ground ice from his personal observations. He reports that the fishermen on the Elbe used to find the baskets which they let down into the river for the purpose of catching eels, when brought up to the surface, often incrusted with ice. Anchors used for mooring their boats, when lost during the summer, frequently appeared in the following winter, being raised by the mass of ice which had formed about them. Their signal buoys sometimes became displaced from the raising of the large stones by the ground ice and caused great inconvenience.

M. Desmarest, a member of the French Academy of Sciences, was among the first of the scientists to make observations on the formation of ground ice. He reports having observed flakes of ice formed at the bottom of running streams increase in thickness five or six inches in a single night. In Ireland's Picturesque Views of the River Thames, published in 1792, the ground ice of that river is mentioned. It is stated: "The water men frequently meet the ice meers, or cakes of ice, in their rise, and sometimes in the underside inclosing stones and gravel brought up by them *ab imo*".

In February of 1827, M. Hugi, President of the Society of Natural History at Soleure, reports that while standing on the bridge over the Aar, when the river was clear of ice, he observed large ice tables continually rising from the bottom, in a vertical direction and with such buoyancy as to rise considerably above the surface, when they immediately sank into a horizontal position and floated down stream.

In 1833 the eminent philosopher, M. Arago, published an interesting paper on the subject in the Annuaire du Bureau des Longitudes for that year[3]. He mentions the following rivers where ground ice is met with and the date of such observation: in the Thames, by Hales, in 1730; in the River Déonie, France, in 1780; in the Elbe, by Beaun, in 1788; in the Teine, Herefordshire, in 1816; in the Rhine, at Strasburg, in 1829; and in the Seine, in 1830.

In the Edinburgh New Philosophical Journal for 1834[4] there is an interesting paper on "Observations on ground ice", by the Rev. Mr. Eisdale, who attempts to explain the phenomenon on an original theory of his own. He states that the ice commences on the bottom and extends upward to the surface, and is produced only in the most rapid and most rugged streams.

The Rev. Dr. Farquharson published two important papers on "Ground gru" in the Philosophical Transactions of 1835 and 1841[5]. His observations were made of the ice in the rivers Don and Leochal, in Aberdeenshire. The conclusions he arrived at are that ground gru is formed by radiation, and he gives a large number of observations, which clearly show this to be the case for the examples which came under his notice.

As early as 1810 writers of that time drew a distinction between three kinds of river ice, if we may judge from an early edition of the Encyclopedia Britannica published at that date. Under the article on ice we find the following:

> Ice forms generally on the surface of the water, but this too, like the crystallization, may be varied by an alteration in the circumstances. In Germany, particularly the northern parts of the country, it has been observed that there are three kinds of ice. 1. That which forms on the surface. 2. Another kind formed in the middle of the water, resembling nuclei or small hail. 3. Ground ice, which is produced at the bottom, especially where there is any fibrous substance to which it may adhere. This is full of cells like a wasp's nest, but less regular, and performs many strange effects in bringing up very heavy bodies from the bottom by means of its inferiority in specific gravity to the water in which it is formed. The ice which forms in the middle of the water rises to the top and then unites in large masses, but the formation both of this and the ground ice takes place only in violent and sudden colds, where the water is shallow and the surface is disturbed in such a manner that the congelation can not take place. The ground ice is very destructive to dykes and other aquatic works. In the more temperate European climates these kinds of ice are not met with.

In Canada three kinds of ice are observed, similar to those just described. These go by the name of sheet or surface ice, anchor ice, and frazil ice. The latter corresponds to what the early writer in the Encyclopedia Britannica states is formed in the middle of the water.

Frazil is the French Canadian expression for spicular ice, meaning cinder ice. It is formed in all rivers or streams flowing too swiftly for surface ice to form, and is produced in such immense quantities in Canadian rivers as to cause, in many cases, serious obstacles to hydraulic development. Anchor ice forms in situ on the bed of a river and often attains a thickness of five or six feet. It has never been observed in Canada to form under a layer of surface ice, because usually such ice is covered by an opaque layer of snow, which acts as an effective check to the radiation of heat from the bottom of a river, which appears to be the real cause of its formation. The writer[6] has measured the temperature of the water in winter both under the surface ice in the St. Lawrence River, opposite Montreal, and in the open water of the Lachine Rapids, when ice was forming rapidly. It was found that the water in this condition becomes slightly undercooled to the order of a few thousandths of a degree, and that the ice which is formed is in a very adhesive state. On the cessation of cold weather the temperature of the water rises slightly above the freezing point and the ice gradually melts. Anchor ice rises from the bottom in mild weather, and also in extreme cold weather under the influence of a bright sun, which has the power to melt it off from the rocks to which it is attached.

The formation of ice[7] has been shown to be accompanied by a small temperature depression in the water, and even in the most severe weather the undercooling is less than a hundredth of a degree centigrade. This fact is already made use of in water powers, where a little steam heat, applied around the wheel gates or directly in the wheel cases of the turbines, warms the surface of the metal sufficiently to prevent the adhesion of the frazil ice crystals. Electric heating is also being applied with some success, and it is safe to say that before long no bad effects from the presence of ice in the water need be feared.

The influence of the sun is everywhere observed in the formation of both frazil and anchor ice—in the former by warming the water and preventing it from becoming undercooled, and in the latter by loosening the masses of anchor ice and causing them to rise. Frazil ice is never observed to possess adhesiveness under a strong sun.

A common sight in the early morning after a cold, clear night, when the sun rises, is the appearance of masses of anchor ice. These rise and float down with the current in great quantity. Boatmen are very careful when crossing a river never to go when these masses are rising, from the

[3] Also, Edinburgh New Philosophical Journal, vol. 15, p. 123 (1833).
[4] Vol. 17, p. 167 (1834).
[5] Vol. 125, p. 329 (1835); vol. p. 131, 37 (1841).
[6] Trans. Roy. Soc. Can. New Series, vol. 2, p. 37 (1896); vol. 3, p. 17 (1897).
[7] Ice Formation, p. 175. New York: John Wiley & Sons, 1906.

danger of being surrounded and caught in a mass of anchor ice, and carried down helpless by the stream into the rapids.

The growth of anchor ice is exceedingly beautiful, taking place in arborescent forms resembling bushy weeds. So hard and thick does it become that it is often very difficult to thrust a sounding rod thru it. It is very granular in structure, as is shown by an examination of the masses that rise to the surface. Thru clear water the ice looks weed-like, with long tentacles rising up out of the mass. It often has immense power in lifting rocks and boulders bodily up, and many of these are carried far down stream, attached to irregular masses of ice. The spongy character of adhering frazil crystals and anchor ice causes them to accumulate slime and infusorial growths from the water, imparting a general brown color to the masses.

If the various facts of common observation in connection with anchor ice be considered, it will be seen that everything points to radiation as the prime cause for its formation. Thus, a bridge or cover prevents the forming of ice underneath. Such a cover acts as a check to radiation, and reflects the heat waves back again to the bottom. Anchor ice rarely grows under a layer of surface ice unless this is clear. It forms on dark rocks more readily than on light ones, which is in accord with what we know in regard to the more copious radiation of heat from dark surfaces. Anchor ice rarely forms under a cloudy sky, either by day or night, no matter how severe the weather, but it forms very rapidly under a clear sky at night. Anchor ice is readily melted off under a bright sun. It seems highly probable then that radiation of heat supplies the necessary cooling to the bottom of a river to form the first layers of ice, after which the growth or building up of the ice is aided by the entangling and freezing of frazil crystals always present in the water. This applies, of course, only to water flowing too swiftly for surface ice to form. The formation of a surface sheet below a stretch of open water or rapids serves to collect immense masses of the fine frazil ice.

Frequently serious damming of the water occurs by the complete stoppage of the channels under the ice. This brings about a rise of water level until sufficient weight has accumulated to enable the water to drive the barrier before it and force a channel for itself. Floods occur as a result of these winter shoves, and frequently occasion considerable damage to property along the river side. The fine frazil ice reaches great depths in many parts of the St. Lawrence River near Montreal, where it is carried under the surface ice by the swift currents of the rapids. Accumulations 80 feet deep, extending from the surface ice to the bottom of the river, were recorded by the members of the Montreal Flood Commission in 1888.

The depth of formation of anchor ice appears to be from forty to forty-five feet in the fresh waters of the Canadian rivers. Along the coast of Newfoundland it has been observed to form as deep as 70 feet in the clearer salt water. The temperature of the water on the bottom need not be exactly at the freezing point for anchor ice to form, the cooling of the bottom by radiation being sufficient to bring it to the freezing point, notwithstanding the slow conduction of heat from the earth.

WEATHER BUREAU MEN AS EDUCATORS.

The following lectures and addresses by Weather Bureau men are reported:

Mr. J. Cecil Alter, May 25, 1906, before the Monday Night Literary Club of Salt Lake City, Utah; also October 23, 1906, before the convention of the Utah Federation of Women's Clubs, at Park City, Utah, on "Some Inside Information on the Weather Outside", illustrated with large hand-made drawings.

Mr. H. W. Richardson, October 4, 1906, before pupils and teachers of the Blaine High School, Superior, Wis., on "The United States Weather Bureau and its Work".

Mr. J. Warren Smith, October 20, 1906, before the Engineer's Club of Columbus, Ohio, on "The Work of the Weather Bureau", illustrated.

Mr. P. H. Smyth, October 27, 1906, before the Farmers' and Teachers' Institute, Olive Branch, Ill., on "Value and Utility of United States Weather Bureau Forecasts and Warnings".

Mr. F. T. Williams, October 26, 1906, before the Church Club, of St. Paul, Minn., on "The Weather Bureau and its Work".

Mr. L. H. Daingerfield, November 19, 1906, before the physiography class of the Centennial High School, Pueblo, Colo., on "The Work of the United States Weather Bureau".

Classes from schools and academies and parties of teachers have visited Weather Bureau offices, to study the instruments and equipment and receive informal instruction, as reported from the following offices:

Boise, Idaho, August 4 and 9, 1906, students from the joint Summer School and Teachers' Institute for southwestern Idaho; also October 27, the physical geography class from the Cole School.

Buffalo, N. Y., October 13, 1906, members of Junior Division No. 2, Boys' Department of the local Young Men's Christian Association.

Cairo, Ill., September 5, 1906, a party of teachers from the Alexander County Teachers' Institute.

Columbus, Ohio, October 23, 1906, a class of special students from the South High School.

Duluth, Minn., September 13, 1906, about thirty-five students of the Freshman class, Duluth State Normal School.

Indianapolis, Ind., October 10, 15, and 17, 1906, the physical geography classes of the Shortridge High School.

Oklahoma, Okla., October 22, 1906, the physical geography class of the Epworth University Academy.

Salt Lake City, Utah, during the school year 1905–6, about five hundred students from the Latter Day Saints' College, the city graded and high schools, the University of Utah, and the district schools of near-by towns.

RECENT ADDITIONS TO THE WEATHER BUREAU LIBRARY.

H. H. KIMBALL, Librarian.

The following titles have been selected from among the books recently received, as representing those most likely to be useful to Weather Bureau officials in their meteorological work and studies. Most of them can be loaned for a limited time to officials and employees who make application for them.

Associacion de Ingenieros y Arquitectos de Mexico.
Anales. Tomo 13. Mexico. 1905. 310 pp. 8°.

Bastin, S. Leonard.
The effects of civilization upon climate. (Monthly review. London. v. 24, September, 1906. Pp. 116–124.)

Beach, Harlan P[age].
A geography and atlas of Protestant missions. 2 vols. viii, 571; 54 pp. 18 pl.

Belgium. Observatoire Royal de Belgique.
Annuaire météorologique. 1905. Bruxelles. 1905. vii, 704 pp. 24°.
Same. 1906. Bruxelles. 1906. vii, 599 pp. 24°.

Bolivia. Ministerio de Colonizacion y Agricultura.
Estudio sobre la climatología de La Paz por Victor E. Marchant Y. La Paz. 1906. 48 pp. 8°.

Bos, H.
Zur Kritik der Lehre von den thermischen Vegetations-Konstanten auch in Bezug auf Winterruhe und Belaubungstrieb der Pflanzen. (S. A.- Verh. des bot. Vereins Brandenburg.) 48 Jahr. 1906. Pp. [62–90]. 8°.

Bowker, R[ichard] R[ogers].
Publications of societies. New York. 1899. v, 181 pp. 8°.

Bracke, Albert.
A la recherche de courants d'air. Mons. [1906.] 93 pp. 8°.

Bremen.
Deutsches meteorologisches Jahrbuch. 1905. Bremen. 1906. xvi, 126 pp. f°.